International Journal of Advanced Research and Review

Smart Water Management and Real-Time Leakage Reduction System Using Embedded IoT Technologies

[1]**Dr.P. Bhaskara Rao,** [2]**Gangisetty Sai Mukesh,** [3]**Mahammad Umar Ansari,**
[4]**Udatha Raja Venkata Purna Chandra Rao,**[5]**Padarthi Mohan Srinivas**
[1]Associate Professor, Dept ELECTRONICS AND COMMUNICATION ENGINEERING, St.Ann's College of Engineering and Technology, Nayunipalli (V), Vetapalem (M), Chirala, Bapatla Dist, Andhra Pradesh – 523187, India
[2,3,4,5]U. G Student, Dept ELECTRONICS AND COMMUNICATION ENGINEERING, St.Ann's College of Engineering and Technology, Nayunipalli (V), Vetapalem (M), Chirala, Bapatla Dist, Andhra Pradesh – 523187, India

ABSTRACT

This paper presents a smart water pipeline monitoring system designed to detect and control water leakages. As water consumption continues to rise, so does the wastage, making efficient water management increasingly important. To address this, a smart monitoring system utilizing the Internet of Things (IoT) is proposed. In the modern era, the applications and benefits of IoT are vast and transformative. The system employs various sensors to measure water flow and contamination. A water flow sensor, based on the principle of the Hall effect, monitors the flow in the pipeline, while a turbidity sensor detects water contamination. The Nodemcu microcontroller, a popular choice for IoT applications due to its interrupt pins, serves as the system's central controller. The data collected by the water flow and turbidity sensors is uploaded to the ThingSpeak cloud server, which is an open, free-to-use platform for storing and analyzing data. The measured values are displayed on the ThingSpeak web server, enabling easy monitoring of the water flow within the pipeline. This system offers a convenient and efficient way to track and manage water usage and quality.

INTRODUCTION

Only 3% of the world's water is fresh, and one-third of it is inaccessible. The demand for water has increased over time due to population growth, rapid industrialization, and rising living standards. Key factors contributing to water pipeline leakage include the material of the pipes and their age. As pipes age, water loss in the network can approach 50%. When a leak occurs, it is often difficult to pinpoint the exact source, and it may take days for authorities to locate and repair the damage. Given the growing number of available wireless networks, selecting the optimal communication method for IoT devices has become increasingly critical. Once data is collected from the IoT device, it is transferred to the cloud for processing and analysis. The processed data is then made accessible to the end-user through various methods, such as phone alerts or email notifications. Additionally, users can monitor their IoT device remotely via a dedicated app, allowing them to track the system's status from anywhere.

LITERATURE SURVEY

"An Enhanced Water Pipeline Monitoring System in Remote Areas using Flow Rate and Vibration Sensors" (by Praveen M Dhulavvagol, Ankita K R, Sohan G, Renuka Ganiger, 2018) introduces a system designed to improve the monitoring of water pipelines, particularly in remote and inaccessible areas. The authors conclude that by incorporating flow rate and vibration sensors, the system offers a cost-effective and efficient solution for monitoring pipelines in these challenging locations. This approach ensures a more reliable and timely response to pipeline failures or issues, ultimately enhancing maintenance strategies. The system is especially valuable in sectors such as water distribution, where pipeline failures can cause significant disruptions, particularly in areas with limited infrastructure. "Water Pipeline Monitoring and Leak Detection using Flow Liquid Meter Sensor," authored by R F Rahmat, I S Satria, B Siregar, and R Budiarto, and published in the IOP Conference Series: Materials Science and Engineering, volume 190, 2016, presents a system designed for monitoring water pipelines and detecting leaks using flow liquid meter sensors. The integration of these sensors provides a reliable solution for tracking the condition of water pipelines. Continuous real-time monitoring allows for early leak detection, which aids in more efficient water distribution management and helps prevent wastage. This approach offers a significant advancement in pipeline maintenance, especially in areas where manual inspections are difficult or impractical.

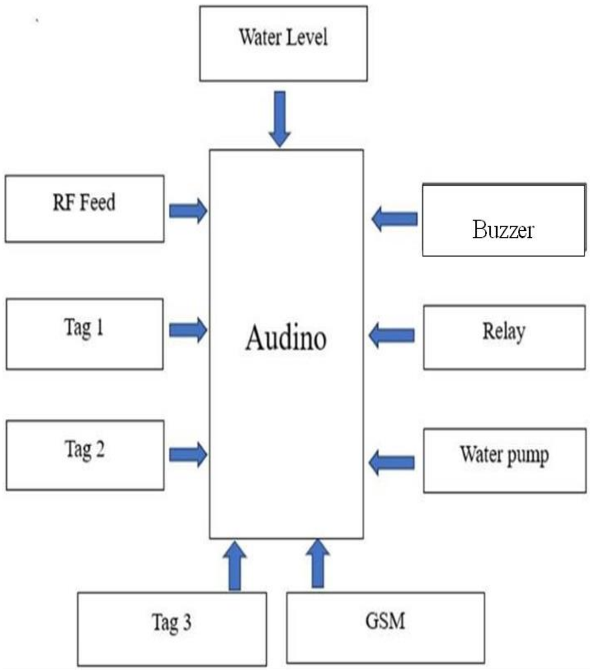
EXISTING SYSTEM

Currently, water pipeline monitoring is performed by workers from water distribution companies. However, it is not feasible for water distributors in urban areas to have workers assigned to every street for pipeline monitoring. Each worker is typically responsible for monitoring 5 to 10 streets, resulting in a high demand for manpower. This approach requires significant human resources to maintain effective monitoring.

PROPOSED SYSTEM

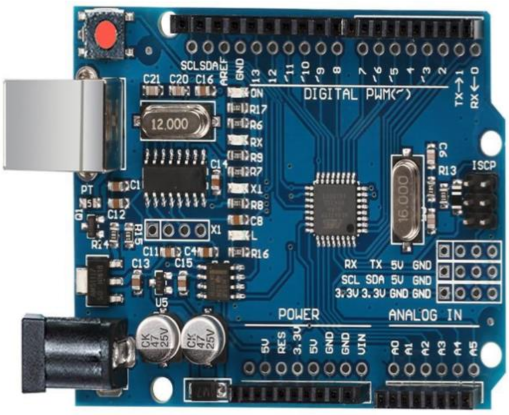
In this system, non-acoustic leak detection is achieved using flow sensors. The YF-S201 water flow sensor calculates the flow rate and monitors the volume of water passing through the pipeline. Additionally, a turbidity sensor is employed to assess the water's contamination level. The primary purpose of the turbidity sensor is to monitor the purity of the water. If a leak occurs and soil enters the pipe, the water's purity is compromised. Therefore, it is crucial to track both the flow rate and water quality. To provide real-time updates, IoT technology is utilized, allowing the microcontroller to send data to a cloud server for further processing. This approach ensures efficient monitoring of both water flow and purity, with enhanced security and remote accessibility for the owner.

BLOCK DIAGRAM



HARDWARE REQUIREMENT

ARDUINO:



The Arduino Uno is an open-source microcontroller board featuring the Microchip ATmega328P microcontroller, developed by Arduino.cc. It comes with a variety of digital and analog input/output (I/O) pins that can be connected to expansion boards (shields) and other circuits. The board includes 14 digital pins, 6 analog pins, and is programmable using the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered either through the USB cable or by an external 9-volt battery, with a voltage range of 7 to 20 volts. The Arduino Uno shares similarities with the Arduino Nano and Leonardo. You can program the board by sending instructions to the microcontroller using the Arduino programming language (based on Wiring), through the Arduino IDE, which is built on Processing.

WATER LEVEL SENSOR:

The water sensor brick is designed for detecting water, and it can be widely used for applications such as rainfall detection, water level monitoring, and liquid leakage detection. The sensor consists of three main components: an electronic brick connector, a 1 MΩ resistor, and several bare conductive wires. The sensor operates by having a series of exposed traces connected to ground, with sensor traces interlaced between the grounded ones. The sensor traces are equipped with a weak pull-up resistor of 1 MΩ, which keeps the sensor trace value high until a drop of water bridges the sensor trace and the grounded trace. This simple circuit can work with the digital I/O pins of an Arduino, or you can use it with analog pins to detect the amount of water that creates contact between the sensor and grounded traces.

WATER PUMP:

A water pump is a device that utilizes both mechanical and hydraulic principles within a piping system to generate sufficient force for moving water to its intended destination. Water pumps have been in use in various forms since ancient civilizations. Today, they are widely employed across diverse sectors, including residential, agricultural, municipal, and industrial applications.

RFID:

A radio frequency identification (RFID) reader is a device used to collect data from an RFID tag, which helps track individual items. Similar to barcodes in concept, RFID technology differs in that the RFID tag does not need to be scanned directly or require a line-of-sight to the reader. This allows for more flexible and efficient tracking.

BUZZER:

A buzzer or beeper is an audio signaling device that can be mechanical, electromechanical, or piezoelectric (often referred to as piezo). These devices are commonly used in applications such as alarm systems, timers, and to provide confirmation of user actions, like a mouse click or keystroke. The sound emitted serves as a clear indication or alert for various events.

GSM:

The GSM system was developed as a digital communication system using the Time Division Multiple Access (TDMA) technique. It digitizes and compresses data, transmitting it through a channel with two separate data streams, each assigned its own specific time slot. This digital system is capable of supporting data rates ranging from 64 kbps to 120 Mbps. GSM networks use various cell sizes, including macro, micro, pico, and umbrella cells, each designed to suit different deployment scenarios. The coverage area of each cell type varies depending on the specific implementation environment.

RELAY:

A relay operates in situations where a low-power signal is needed to control a circuit.

It is also useful when a single signal must control multiple circuits. The use of relays began with the invention of the telephone, where they played a key role in switching calls at telephone exchanges. Relays were also employed in long-distance telegraphy to route signals from one source to another destination. With the advent of computers, relays were further used to perform Boolean and other logical operations. In high-power applications, relays are often used to control electric motors and similar devices, and these are known as contactors.

CONCLUSION

The main objective of this system is to detect leaks in water pipelines, offering significant benefits for smart cities where numerous pipelines are in place and leaks are common. By utilizing this system, leak detection becomes much easier, enabling quick identification and resolution of related issues. The system is also highly beneficial for water distribution networks in remote locations. Water flow sensors, as demonstrated through experimental results, are ideal for tracking and detecting leaks in pipeline control systems. With the widespread presence of water pipelines and frequent leaks in urban areas, this system provides an efficient solution. Currently, leak monitoring is done by water distribution staff, but this system facilitates faster problem resolution. Additionally, it can be applied to water delivery systems in remote areas.

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